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In Vino Veritas: The Economics of Drinking

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Jan Heufer[1]

In Vino Veritas: The Economics of Drinking

Abstract

It is argued that drug consumption, most commonly alcohol drinking, can be a technology to give up some control over one's actions and words. It can be employed by trustworthy players to reveal their type. Similarly alcohol can function as a "social lubricant" and faciliate type revelation in conversations. It is shown that both separating and pooling equilibria can exist; as opposed to the classic results in the literature, a pooling equilibrium is still informative. Drugs which allow a gradual loss of control by appropriate doses and for which moderate consumption is not addictive are particularly suitable because the consumption can be easily observed and reciprocated and is unlikely to occur out of the social context. There is a tradeoff between the efficiency gains due to the signaling effect and the loss of productivity associated with intoxication. Long run evolutionary equilibria of the type distribution are considered. If coordination on an exclusive technology is efficient, social norms or laws can raise efficiency by legalizing only one drug.

JEL Classification: C72, D82

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1 TU Dortmund University and Ruhr Graduate School in Economics. – *I am grateful to my advisor Wolfgang Leininger for his support and comments. Thanks to Jörg Franke and Yiquan Gu for helpful comments and discussions. Views expressed represent exclusively the author's own opinions.* – *All correspondence to Jan Heufer, TU Dortmund, Department of Economics and Social Science, 44221 Dortmund, Germany, e-mail: jan.heufer@tu-dortmund.de.*

"I don't trust a man who doesn't drink . . . you don't know what he's up to."
–Szwed (1966), quoting an anonymous Newfoundlander

1 INTRODUCTION

Social drinking is widespread in many areas of the world, and there is at least anecdotal evidence that participation in moderate consumption within a social context can be beneficial for individuals.[1] It is argued in this paper that social drug consumption, in particular alcohol drinking, can be used directly to partially reveal a player's personality, in particular his trustworthiness, and, in a separating equilibrium, can serve as a credible signal. A drug is thought of as a technology which can be used to voluntarily give up some degree of control over one's action and words; if this consumption takes place within a social context both the consumption itself and the drug-induced behavior is observable.

While the revelation of truth after the consumption of alcohol is proverbial in many cultures, it suffices for the idea of this paper that the observation of alcohol-induced behavior can be used to better estimate a person's personality type, or that alcohol as a "social lubricant" heightens social interaction.[2] If alcohol can be used to give others better information about one's personality, the social consumption of alcohol can benefit those who would like to honestly reveal their type. For example, if players play a game of trust, a trustworthy person might suffer a subjective disutility from exploiting trust and therefore choose to reward trust. If his trustworthiness is common knowledge, this player would be trusted by others if this leads to a higher payoff for both. If his trustworthiness is not observable, other players might not be willing to take the risk of trusting him. The trustworthy player, therefore, has an incentive to employ alcohol in order to credibly reveal information about himself. A non-trustworthy player may not be willing to imitate the behavior of the trustworthy players.[3]

In general, many different drugs are potential signals. If intoxication is associated with a loss of productivity, e.g. a reduction in the pie which is to be split up, there is a natural trade off between the gains due to revelation of trustworthiness and the decrease in productivity. If the drug is highly addictive, it would also be used out of the social context, a use which is only unproductive.

Besides being useful to obtain a better estimate of someone's type, a suitable drug should therefore i) be not addictive for moderate consumption, ii) have only short term

[1] History is also rich in examples of alcohol usage. For example, Rolleston (1927) gives an account of alcohol usage in ancient Greece and Rome; Feldman (1927) adds information on alcohol in ancient jewish literature, citing a Talmud proverb "When wine comes in, the secret comes out". Walsh (2000) analyzes social drinking in biblical tales, noting that alcohol "increased intimacy" and that "[w]ith heavy drinking comes heightened trust as well as a consequent increased risk of its betrayal".

[2] For example, in an experiment Higgins and Stitzer (1988) found that "[a]lcohol produced a significant dose-dependent increase in total speech", which was independent of a social context, which suggests that it is not the social context which increases talkativeness but alcohol itself.

[3] This is obviously a problem for those who choose to abstain for other reasons. Paton-Simpson (2001) analyzes norms that govern minimum levels of consumption in social settings. In particular, he finds that non-drinkers frequently encounter hostility in response to their deviance, which ranges from subtle nonverbal cues to threats of physical force.

effects, iii) allow a gradual degree of loss of control which can be easily observed and reciprocated by others. Alcohol satisfies these requirements.

If it is efficient for a society to employ a universal, exclusive technology, then it is efficient to coordinate on one drug. Laws or social norms can then be used to enforce the use of only one technology that is well suited for the purpose. This can help to explain why alcohol is legal in many countries, whereas other drugs which are just as harmful or even less harmful from a medically point of view are illegal.[4]

Furthermore, competing suppliers of signaling technologies such as religions have incentives to discourage drug use. This can help to explain why many religions recommend or require abstinence.

From a modelling point of view, the approach in this paper is also novel: We model the strategic improvement of the informational content of a noisy exogenous signal (similar to the one used in Frank 1987).

The rest of the paper is organized as follows. Section 2 gives a simple example of a game of trust in which trustworthy players employ a drug to reveal their type. Section 3 introduces a more detailed model with a noisy exogenous signal. Section 4 analyzes the model when the noisy signal is normally distributed. It is shown that both separating and pooling equilibria can arise. In a separating equilibrium, only the trustworthy types consume the drug. The pooling equilibrium differs from usual pooling equilibria considered in the literature on asymmetric information: Both types of players consume the same amount of the drug, but this behavior is nonetheless informative. Long run evolutionary stable equilibria of type distributions are considered. Section 5 discusses the results of the model and possible extensions. Section 6 concludes.

2 A SIMPLE EXAMPLE

To start with a simple example, assume that two players 1 and 2 play a game of trust depicted in Figure 1.[5] The dotted line indicated the information set of player 1, i.e. he does not know at which node he is. Player 2 can be either of two types θ^i, $i \in \{L, H\}$, where θ^L can be interpreted as the non-trustworthy type and θ^H as the trustworthy type. The probability that player 2 is trustworthy is $\text{Prob}(\theta^H) = \lambda$. The idea is that a player of type θ^H will suffer a (subjective) disutility from not rewarding another person's trust in him, whereas a player of type θ^L will not experience such emotions and benefit from exploiting player 1's trust.

Player 1 will choose a strategy $t_1 \in \{\text{T}, \text{NT}\}$ (trust or not trust), player 2 will choose a strategy $t_2 \in \{\text{C}, \text{NC}\}$ (cooperate or not cooperate). If the type of player 2 were observable to player 1, the unique (subgame perfect) equilibrium of this game were the choice of NC by 2 and NT by 1 if player 2 is not trustworthy, and the choice of C by 2 and T by 1 if player 2 is trustworthy. Because the type of player 2 is not observable by player 1, the (perfect Bayesian) equilibrium strategy for player 1 is to play T if $\lambda > 2/3$ and to play NT if $\lambda < 2/3$.

[4] See for instance Nutt et al. (2007). By the authors' assessment of harm, alcohol ranks higher than cannabis, LSD, and ecstasy, and many other illegal drugs.

[5] For one-shot experiments with this game structure see, for example, Berg et al. (1995) and Bolle (1998). For a theoretical model with gift giving and long term relationships, see Bolle (2001).

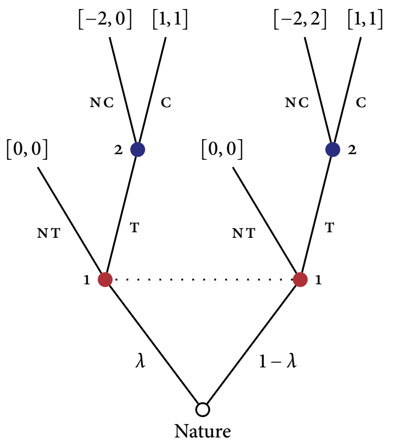


Figure 1: A game of trust. Payoff of player i is given by the ith element of the payoff vector.

Suppose that $\lambda < 2/3$. If player 2 is of type θ^H, he could potentially benefit from credibly revealing his type to player 1. Suppose before the game is played, the two players have the opportunity to engage in an informal conversation accompanied by drug consumption. Both players know from experience that if a player consumes an amount of at least d then his type θ will be revealed. Suppose the cost of this drug consumption is also d. Then if $d \in (0,1)$, player 2 of type θ^H will consume an amount of d and reveal his type; the equilibrium payoff vector in the game will then be $(1, 1-d)$. If player 2 were of type θ^L he would prefer not to incur the costs of the consumption, as he has nothing to gain from it.

3 AN ILLUSTRATIVE MODEL

3.1 *Preliminaries*

For this section and the next, we will interpret the drug as "alcohol" and refer to "drug consumption" as "drinking". Consider the following game Γ:

There are $N \geq 2$ players, where N is a multiple of two. Players are of type θ^i, $i \in \{L, H\}$.

1. *Stage* *Nature assigns each player a type θ, where $\text{Prob}(\theta^H) = \lambda$ with $\lambda \in [0,1]$. Players know their own type and they know λ, but do not know the type of any other player.*

2. *Stage* *The players simultaneously decide which amount $d \geq 0$ of alcohol they want to consume. The consumption and the successive alcohol-induced behavior is observable by all. The cost of the consumption is the same for both types: $c(d) \geq 0$, with $c(0) = 0$, $c' > 0$ and $c'' > 0$*

3. *Stage* *Every player is randomly matched with another player, with one randomly chosen player being labeled "player 1" and the other player being labeled "player 2"; both*

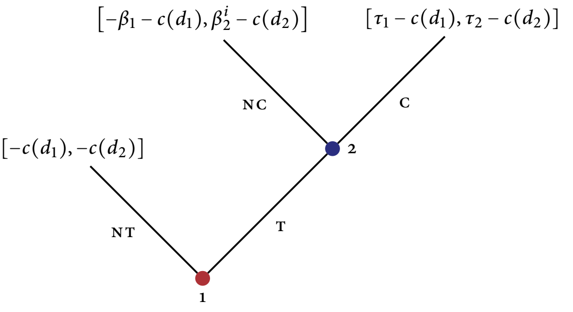


Figure 2: A game of trust; part of the game Γ. The parameters $\tau_j > 0$, $j \in \{1, 2\}$, are the payoffs of player 1 and 2 when player 2 cooperates after player 1 trusted him; $-\beta_1 < 0$ is the payoff of player 1 when his trust is abused; β_2^i is the payoff of player 2, type θ^i, when player 2 abuses the trust of player 1. We have $\beta_2^L > \tau_2 > \beta_2^H$, i.e. a trustworthy player 2 (type θ^H) prefers cooperation wheras a non-trustworthy player 2 (type θ^L) prefers to abuse the trust.

players have equal chances to be "player 1" or "player 2". The players know their labels. The game of trust as depicted in Figure 2 is played, with $\min\{\tau_1, \tau_2, \beta_1\} > 0$ *and* $\beta_2^L > \tau_2 > \beta_2^H$.

Note that the players' types are assigned independently, i.e. a player cannot conclude that given his own type, the probability of being matched with a player of type H is different from λ.

The players (involuntarily) emit a noisy signal $s \in \mathbb{R}$. The signal is drawn from a distribution function $F^i(s \mid d^i)$ with associated probability density function $f^i(s \mid d^i)$, where $i \in \{L, H\}$ and d^i is the alcohol consumption of type θ^i. To distinguish the noisy signal s from the endogenous signaling by drinking (see below), we will always refer to s as the "noisy signal". For $d = d^L = d^H$, the noisy signal is informative about a player's type in the sense that the higher the noisy signal the more likely it is that it was drawn from $f^H(s \mid d)$:

Assumption 1. *The two probability density functions satisfy the* monotone likelihood ratio property*: For any* $s_b > s_a$*, we have*

$$\frac{f^H(s_b \mid d)}{f^L(s_b \mid d)} \geq \frac{f^H(s_a \mid d)}{f^L(s_a \mid d)}.$$

Player 2 of type θ^L will not cooperate in the game of trust because $\beta_2^L > \tau_2$, whereas player 2 of type θ^H will cooperate because $\tau_2 > \beta_2^H$. Given player 1's payoff structure, player 1 will want to trust a player of type θ^H and distrust a player of type θ^L. This is summarized in the following lemma.

Lemma 1. *If types are observable, the subgame perfect equilibrium of the subgame of trust in* Γ *is* (NT,NC) *if player 2 is of type* θ^L *and* (T,C) *if player 2 is of type* θ^H.

Let $q^i = q(\theta^i, \cdot)$, $i \in \{L, H\}$, denote the probability that a player 2 of type θ^i is trusted at stage 3 of the game Γ (the subgame of trust). The equilibrium values for q^i will be derived in the next section. The expected utility of player 1 at stage 3 is

$$\mathrm{E}[U_1(d)] = \lambda\, q^H \tau_1 - (1-\lambda)\, q^L \beta_1 - c(d), \tag{1}$$

where $c(d)$ is the cost of player 1 from drinking at stage 2. The expected utility for player 2 for the two different types at stage 3 is

$$\mathrm{E}[U_2(\theta^L, d)] = q^L \beta_2^L - c(d), \tag{2}$$
$$\mathrm{E}[U_2(\theta^H, d)] = q^H \tau_2 - c(d). \tag{3}$$

The expected utility of a player at stage 1 is then

$$\mathrm{E}[U(\theta^L, d)] = \tfrac{1}{2}\mathrm{E}[U_1(d)] + \tfrac{1}{2}\mathrm{E}[U_2(\theta^L, d)], \tag{4}$$
$$\mathrm{E}[U(\theta^H, d)] = \tfrac{1}{2}\mathrm{E}[U_1(d)] + \tfrac{1}{2}\mathrm{E}[U_2(\theta^H, d)], \tag{5}$$

because players are labeled "player 1" or "player 2" with equal probability.

3.2 *Equilibria*

Only pure-strategy equilibria are considered, so a strategy at stage 2 of Γ is a mapping between types and alcohol consumption. Let $D = \mathbb{R}_+$ be the strategy space at stage 2, and d^i be the strategy (alcohol consumption) of type θ^i. Let $\mathbf{d} = (d^L, d^H)$ denote the strategy vector of the two types. Let the function $\omega^i = \omega(\theta^i \mid s, \mathbf{d}) \in [0,1]$ represent the belief of a player that the other player he is matched with at stage 3 is of type θ^i, given the noisy signal s and the strategies $\mathbf{d}$.[6] Let $\mathbf{t}_1 = (t_1^L, t_1^H) \in \{\textsc{t}, \textsc{nt}\}^2$ and $\mathbf{t}_2 = (t_2^L, t_2^H) \in \{\textsc{c}, \textsc{nc}\}^2$ denote the strategy vector of the two types of player 1 and player 2 at the subgame of trust. Define

$$T^i(d^L, d^H, t_2^i) := \begin{cases} \tfrac{1}{2}\, q(\theta^i, \mathbf{d})\, \beta_2^i - c(d^i) & \text{if } t_2^i = \textsc{nc} \\ \tfrac{1}{2}\, q(\theta^i, \mathbf{d})\, \tau_2 - c(d^i) & \text{if } t_2^i = \textsc{c}, \end{cases} \tag{6}$$

and

$$V(\theta^L, d^L, d^H) := \tfrac{1}{2}\, q(\theta^L, \mathbf{d})\, \beta_2^L - c(d^L), \tag{7}$$
$$V(\theta^H, d^L, d^H) := \tfrac{1}{2}\, q(\theta^H, \mathbf{d})\, \tau_2 - c(d^H). \tag{8}$$

Definition 1. *A pure-strategy perfect Bayesian equilibrium (PBE) is given by type-contingent strategy profiles $\mathbf{d} = (d^L, d^H)$, $\mathbf{t}_1 = (t_1^L, t_1^H)$, and $\mathbf{t}_2 = (t_2^L, t_2^H)$, and beliefs ω, where*

i) $T^L(d^L, d^H, t_2^L) \geq T^L(d', d^H, t_2^L)$ and $T^H(d^L, d^H, t_2^H) \geq T^H(d^L, d', t_2^H)$ for all $d' \in D$,

[6] In a slight abuse of notation, we will also write $\omega(\theta^i \mid s, d^L, d^H)$ and $q(\theta^i, d^L, d^H)$.

ii) for all $d \in D$, $\omega(\theta^i \mid s, d^L, d^H)$ is such that if $\{\theta^i \mid d^i = d\} \neq \varnothing$ then

$$\omega(\theta^i \mid s, \mathbf{d}) = \frac{\lambda f^i(s \mid d^i)}{\lambda f^i(s \mid d^i) + \mathbf{I}(\mathbf{d})\,[1-\lambda]\, f_j(s \mid d_j)}, \tag{9}$$

where $i, j \in \{i, j\}$, $i \neq j$, and

$$\mathbf{I}(\mathbf{d}) = \begin{cases} 1 & \text{if } d^L = d^H \\ 0 & \text{if } d^L \neq d^H, \end{cases}$$

iii) strategy t_1^i, $i \in \{L, H\}$, is optimal given the belief ω, and

iv) strategy t_2^i, $i \in \{L, H\}$, is optimal given the strategy of the other player and the belief ω.

It can be easily seen that condition iv only depends on the type of player; in any equilibrium, we must have $\mathbf{t}^2 = (\text{C}, \text{NC})$.

The belief function $\omega(\theta^i \mid s, \mathbf{d})$ is the same for both player types and denotes the player's conditional probability that the other player's type he is matched with at stage 3 of Γ is θ^i (see e.g. Fudenberg and Tirole (1991), pp. 331–333).

We call an equilibrium a *pooling equilibrium* if both types choose the same strategy (i.e. $d^L = d^H$), and a *separating equilibrium* if the two types choose different strategies (i.e. $d^L \neq d^H$).

Given the noisy signal s and the payoffs, player 1 will trust player 2 if his expected payoff from trusting is non-negative, i.e. is at least as high as the payoff from not trusting. In equilibrium the expected payoff needs to be based on the belief ω of player 1. Player 1 will therefore trust if

$$\omega(\theta^H \mid s, \mathbf{d})\, \tau_1 - \omega(\theta^L \mid s, \mathbf{d})\, \beta_1 \geq 0, \tag{10}$$

which is equivalent to

$$\frac{f^H(x \mid d)}{f^L(x \mid d)} \geq \left[\frac{1-\lambda}{\lambda}\right] \frac{\beta_1}{\tau_1} \tag{11}$$

if $d^L = d^H = d$ because $\omega(\theta^L \mid s, \mathbf{d}) = 1 - \omega(\theta^H \mid s, \mathbf{d})$.

We can now derive the values for $q(\theta^i, \mathbf{d})$ in equilibrium. The probability that a player 2 of type θ^i is trusted is

$$q(\theta^i, \mathbf{d}) = \operatorname{Prob}\left(\omega(\theta^i \mid s, \mathbf{d}) \geq \frac{\beta_1}{\beta_1 + \tau_1} \,\middle|\, \theta^i\right). \tag{12}$$

Note that $\beta_1/[\beta_1 + \tau_1] < 1$ so that when $d^L \neq d^H$ we have with $\omega(\theta^H \mid s, d^L, d^H) = 1$ that $q(\theta^H, d^L, d^H) = 1$, and similarly $q(\theta^L, d^L, d^H) = 0$. Let s^* be the value of s that solves $\omega(\theta^H \mid s, \mathbf{d}) = \beta_1/[\beta_1 + \tau_1]$. We can therefore write

$$q(\theta^H, \mathbf{d}) = \begin{cases} 1 - F^H(s^* \mid d) & \text{if } d^H = d^L = d \\ 1 & \text{if } d^H \neq d^L \end{cases} \tag{13}$$

and

$$q(\theta^L, \mathbf{d}) = \begin{cases} 1 - F^L(s^* \mid d) & \text{if } d^H = d^L = d \\ 0 & \text{if } d^H \neq d^L. \end{cases} \tag{14}$$

Therefore, if the two types θ^L and θ^H choose different amounts of alcohol d^L and d^H, then player 1 will be able to perfectly distinguish the two types. Together with Lemma 1 this leads to the following observations:

Lemma 2. *In any separating equilibrium of* Γ*, the equilibrium of the subgame of trust is* $(t_1^i, t_2^L) =$ *(NT,NC) if player 2 is of type* θ^L *and* $(t_1^i, t_2^H) =$ *(T,C) if player 2 is of type* θ^H*.*

Lemma 3. *In any separating equilibrium of* Γ *players of type* θ^L *will choose* $d = 0$*.*

Proof Lemma 2 implies that player 2 of type θ^L will have an equilibrium payoff of $0 - c(d)$. With $c(0) = 0$ and $c' > 0$, his optimal amount of alcohol is $d = 0$. ■

4 EQUILIBRIA WITH A NORMALLY DISTRIBUTED SIGNAL

For further equilibrium analysis it is assumed that the noisy signal s is drawn from a normal distribution with mean μ^i, $i \in \{L, H\}$, and standard deviation $\sigma(d) = \sigma^L(d) = \sigma^H(d)$. Without loss of generality, we can set μ^L to zero. The standard deviation is assumed to decrease in d, i.e. $\sigma'(d) < 0$. The distribution obviously satisfies the monotone likelihood ratio property (Assumption 1). We record the following lemma:

Lemma 4. *The parameter* λ *enters the function* $q(\theta^i, \mathbf{d})$ *via the belief function. Both* $q(\theta^L, \mathbf{d})$ *and* $q(\theta^H, \mathbf{d})$ *vary continuously in* λ *and strictly increase in* λ *for* $\lambda \in (0, 1)$*.*

Proof See appendix.

4.1 *Drinking as a Binary Choice*

Suppose that the strategy space is given by $D = \{0, 1\}$, i.e. a player can only choose between not drinking and drinking an amount of one unit. Let $c = c(1)$ denote the costs of drinking. We have

$$q(\theta^H, \mathbf{d}) = \begin{cases} 1 - \Phi_{\mu^H, \sigma(d)^2}(s^*(d)) & \text{if } d^L = d^H = d \\ 1 & \text{if } d^L \neq d^H \end{cases}$$

and

$$q(\theta^L, \mathbf{d}) = \begin{cases} 1 - \Phi_{0, \sigma(d)^2}(s^*(d)) & \text{if } d^L = d^H = d \\ 0 & \text{if } d^L \neq d^H, \end{cases}$$

where Φ denotes the normal distribution function and $s^*(d)$ is the threshold value of the noisy signal needed for player 2 to be trusted by player 1.

For $\lambda = 0$ no player will be trusted, and for $\lambda = 1$ all players will be trusted. For these cases we will have $d = 0$ given consistent beliefs. Besides these two cases, there are three types of equilibria to be considered: A seperating equilibrium in which type θ^L refrains from drinking wheras type θ^H drinks an amount of one unit; a pooling equilibrium in which both types drink an amount of one unit, and a pooling equilibrium in which both types abstain. As it turns out, all types of equilibria can arise.

Proposition 1. *All three equilibrium types (separating, pooling with and without drinking) can arise, given suitable parameter values. In particular, there exist parameter values β, τ, c, μ, σ and thresholds $0 < \underline{\lambda} < \bar{\lambda} < 1$ such that*

(i) for $\lambda \in (0, \underline{\lambda})$, there exist only separating equilibria;

(ii) for $\lambda = \underline{\lambda}$, there exist only a separating and a pooling equilibrium with drinking;

(iii) for $\lambda \in (\underline{\lambda}, \bar{\lambda})$, there exist only pooling equilibria with drinking;

(iv) for $\lambda = \bar{\lambda}$, there exist only pooling equilibria with and without drinking;

(v) for $\lambda \in (\bar{\lambda}, 1]$, there exist only pooling equilibria without drinking.

Proof Without loss of generality, we can normalize the costs of drinking to unity ($c = 1$) and focus on the the payoffs τ and β. Note that with $c = 1$ we must have $\tau^i > 2$ to ensure that not drinking is not a dominant strategy.

(i): Three conditions need to be satisfied. They all regard the payoff of player 2 at stage 3 of the game Γ.

1. The payoff of type θ^H from separation has to be greater than the payoff of θ^H from pooling with drinking. This condition will always be satisfied for $c > 0$, as can be easily checked.

2. The payoff of type θ^H from separation has to be greater than the payoff of θ^H from pooling without drinking, i.e.

$$½\, \tau_2 - c > ½\, q(\theta^H, 0, 0)\, \tau_2.$$

3. The payoff of type θ^L from pooling with drinking has to be less than zero, which is the payoff of type θ^L for separation, i.e.

$$½\, q(\theta^L, 1, 1)\, \beta_2^L - c < 0.$$

Because $q(\theta^i, \cdot)$ is strictly increasing as a function of λ (Lemma 4), for condition 2 it suffices to show that the λ^* which solves $½\, \tau_2[1 - q(\theta^H, 0, 0)] = c$ is such that $\lambda^* \in (0, 1)$. The explicit solution for λ^* is given in the appendix; it is shown that we have indeed $0 < \lambda < 1$. For condition 3, it suffices to show that the $\lambda^\dagger$ which solves $½\, q(\theta^L, 1, 1)\, \beta_2^L = c$ is such that $\lambda^\dagger \in (0, 1)$, which is also shown in the appendix. Furthermore, it is shown that $\lambda^\dagger > \lambda^*$ if β_2^L / τ_2 is large enough, and we let $\underline{\lambda} := \lambda^*$.

(ii): For $\lambda = \underline{\lambda}$ players of type θ^L are indifferent between drinking and not drinking. Players of type θ^H will drink in any case if $\lambda^\dagger > \lambda^*$.

(iii): Two conditions need to be satisfied. They both regard the payoff of player 2 at stage 3 of the game Γ.

1. The payoff of type θ^H from a pooling situation with drinking has to be greater than the payoff of θ^H from a pooling situation without drinking, i.e.

$$½\, q(\theta^H, 1, 1)\, \tau_2 - c > ½\, q(\theta^H, 0, 0)\, \tau_2. \tag{15}$$

2. The payoff of type θ^L from a pooling situation with drinking has to be positive, i.e.

$$½\, q(\theta^L, 1, 1)\, \beta_2^L - c > 0. \tag{16}$$

For condition 1 it is sufficient that the λ' that solves $½\, \tau_2 \left[q(\theta^H, 1, 1) - q(\theta^H, 0, 0)\right] = c$ is greater than $\underline{\lambda}$ and that $q(\theta^H, 1, 1) > q(\theta^H, 0, 0)$ for $\lambda \in (0, \lambda')$. This is shown in the appendix. Let $\bar{\lambda} := \lambda'$. Condition 2 is satisisfied when $\underline{\lambda} < \bar{\lambda}$ as separation is not sustainable for $\lambda > \underline{\lambda}$ (see proof of i).

(iv): For $\lambda = \bar{\lambda}$, type θ^L imitates and type θ^H is indifferent between drinking and not drinking because $q(\theta^H, 1, 1) = q(\theta^H, 0, 0)$.

(v): If $\bar{\lambda} < 1$ (shown in the appendix), then for $\lambda \in (\bar{\lambda}, 1)$ the payoff from a pooling equilibrium without drinking will be higher than the payoff from a pooling equilibrium without drinking for type θ^H. For $\underline{\lambda} < \bar{\lambda}$, separation is not sustainable (see proof of iii).

■

The three types of equilibria are depicted in Figure 3. The figure shows the payoff functions for type θ^L with drinking and for type θ^H with and without drinking. For low λ the payoff of type θ^L is negative if he decides to drink. Type θ^L will therefore not drink, and separation is sustainable – type θ^H will earn a high payoff of $\tau_2 - c$. As λ increases above the threshold $\underline{\lambda}$ the payoff of type θ^L in a pooling situation is positive. Type θ^L will therefore drink (i.e. he will imitate type θ^H) and separation is no longer sustainable. For $\lambda > \underline{\lambda}$ type θ^H will compare his payoff from drinking with the payoff from abstaining. For $\lambda \in (\underline{\lambda}, \bar{\lambda}]$ the payoff from drinking is higher than from abstaining. Type θ^H will therefore drink and type θ^L will imitate θ^H by drinking as well. As λ increases above the threshold $\bar{\lambda}$ type θ^H will abstain and type θ^L will imitate θ^H by abstaining as well.

4.2 *Continuous Choice*

Suppose now that drinking is a continuous choice, i.e. $D = \mathbb{R}_+$. We demonstrate by examples that all three types of equilibria can exist. Figure 4 shows indifference curves for type θ^H for the payoff from pooling, i.e. all combinations of λ and d which yield the same payoff. For any given λ the optimal amount of alcohol d is at the point on a vertical line through the point $(\lambda, 0)$ at which the indifference curve is just tangent to that line. A curve through all these points is depicted; it shows the optimal d in a pooling situation for all λ.[7]

Figure 5 shows the combination of all λ and d at which type θ^L is indifferent between drinking and abstaining, given that type θ^H drinks. For all combinations of λ and d on or above this curve separation can be sustained – the shaded area shows all combinations of

[7] The curve showing the optimal d is discontinuous at one point because for high λ $q(\theta^H, \mathbf{d})$ is decreasing in d for small d.

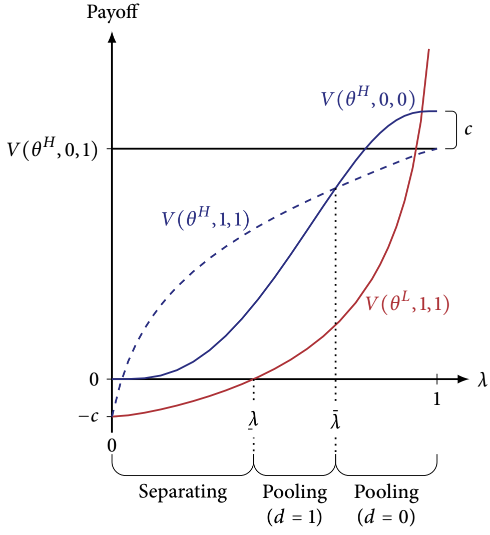


Figure 3: Three possible equilibrium types (example with $\beta_1 = \beta_2^L = 2$, $\tau_1 = \tau_2 = 1$, $\mu^H = 1$, $\sigma(1) = 1/2$, $\sigma(0) = 11/10$, $c = 7/100$).

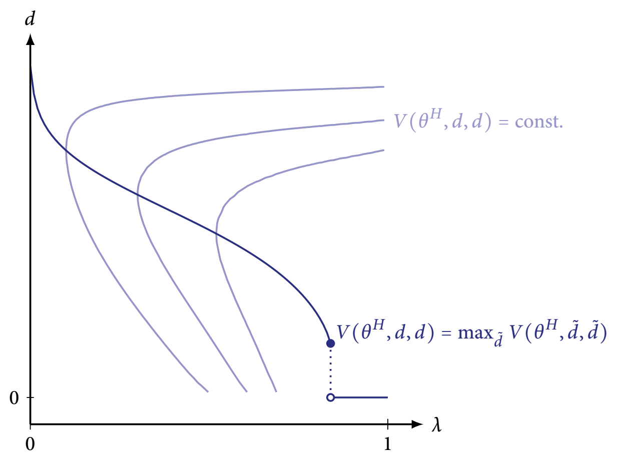


Figure 4: The d which maximizes payoff for type θ^H in a pooling situation for given λ and indifference curves (example with $\beta_1 = 2$, $\beta_2^L = 3$, $\tau_1 = \tau_2 = 1$, $\mu^H = 6/5$, $\sigma(d) = 1 - \sqrt{d}$, $c(d) = 6/5\, d^3$).

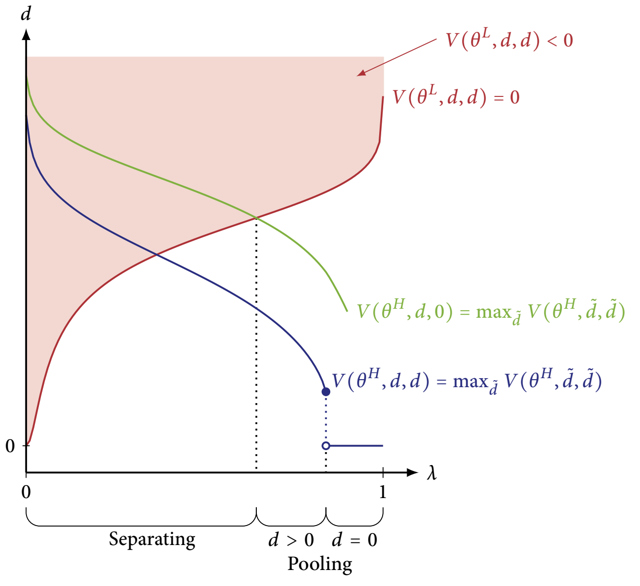


Figure 5: Three possible equilibrium types (example with $\beta_1 = 2$, $\beta_2^L = 3$, $\tau_1 = \tau_2 = 1$, $\mu^H = 6/5$, $\sigma(d) = 1 - \sqrt{d}$, $c(d) = 6/5\, d^3$).

λ and d for which the payoff of type θ^L of pooling with drinking is negative. The second curve shows the combinations of λ and d at which, given λ, type θ^H receives the same payoff from separation and pooling assuming that he chooses the optimal d for pooling. Below this curve his payoff from separation exceeds the payoff from pooling. As long as this curve is in the shaded area, the payoff from separation is higher than that of pooling for type θ^H, and separation is sustainable. Therefore, for low λ, type θ^H will choose a d on the curve representing $V(\theta^L, 0, 0) = 0$ and we have a separating equilibrium. For higher λ, separation is not sustainable and type θ^H will choose the optimal d for pooling and will be imitated by type θ^L.

Figures 6 and 7 also illustrate a separating and a pooling equilibrium. Here the payoff of player 2 at stage 3 of Γ is shown for two different values of λ. Figure 6 shows a separating equilibrium with a low λ: At the value of d at which the payoff of type θ^L is zero, the payoff of type θ^H from separating is higher than the maximal payoff type θ^H can achieve with pooling. Figure 7 illustrates the opposite case.

4.3 *The Type Distribution in a Long Run Equilibrium*

In a similar model without endogenous signaling but noisy exogenous signals, Frank (1987) investigates the equilibrium proportion of cooperative and non-cooperative types in a population. In an equilibrium in which both types exist, the expected payoff of the two types have to be equal in the long run – a type cannot endure if he is performing

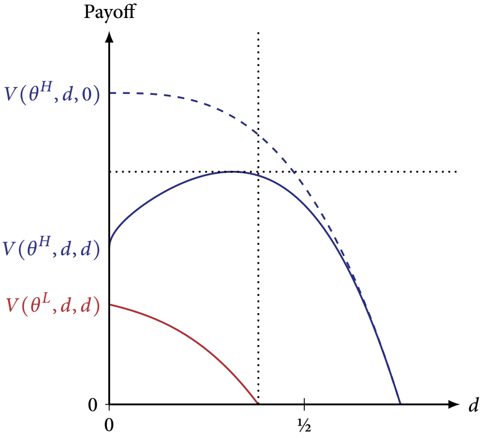


Figure 6: A separating equilibrium (example with $\lambda = {}^{55}\!/_{100}$, $\beta_1 = \beta_2^L = 2$, $\tau_1 = \tau_2 = 1$, $\mu^H = 1$, $\sigma(d) = 1 - \sqrt{d}$, $c(d) = {}^{6}\!/_{5}\, d^3$).

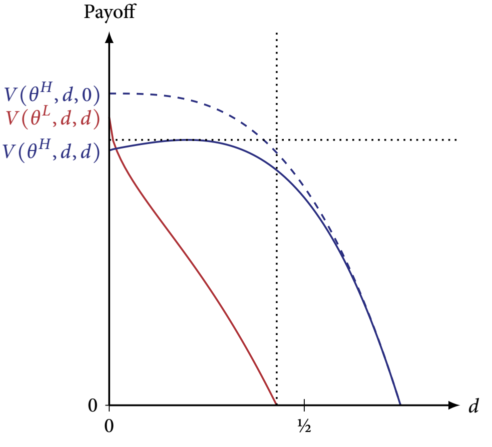


Figure 7: A pooling equilibrium (example with $\lambda = {}^{75}\!/_{100}$, $\beta_1 = \beta_2^L = 2$, $\tau_1 = \tau_2 = 1$, $\mu^H = 1$, $\sigma(d) = 1 - \sqrt{d}$, $c(d) = {}^{6}\!/_{5}\, d^3$).

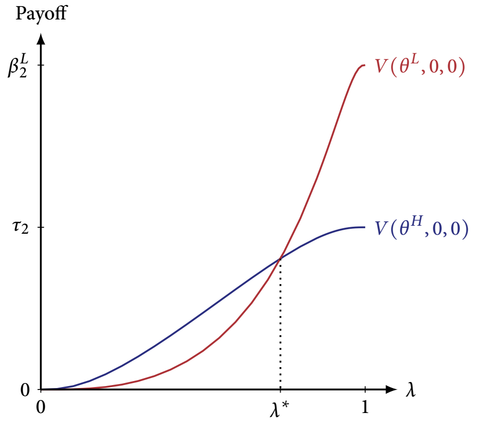


Figure 8: Expected payoffs for the two types (example with $\beta_1 = \beta_2^L = 2$, $\tau_1 = \tau_2 = 1$, $\mu^H = 1$, $\sigma = 9/10$).

worse than other types. If drinking is not an option, then in the model presented in this paper the equilibrium fraction of trustworthy types is given by the λ^* that solves $q(\theta^H, 0, 0)/q(\theta^L, 0, 0) = \beta_2/\tau_2$. For the equilibrium to be (evolutionarily) stable the payoff function of type θ^L has to intersect the payoff function of type θ^H from below. Figure 8 depicts such an equilibrium.

The mechanism which leads to the equilibrium value of λ is not explicitly modelled in Frank (1987). Without drinking as an endogenous signal it is plausible to assume an evolutionary process guided by natural selection. With drinking, cultural transmission and imitation during socialization in early years appears to be better suited as a selection mechanism.

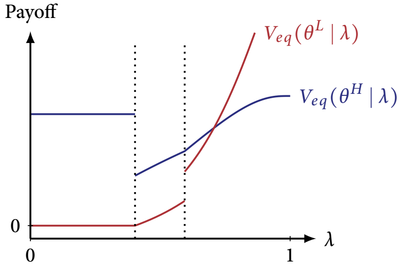
Friedman and Singh (2009) introduce the notion of evolutionarily stable perfect Bayesian equilibrium, which is also employed in a model on social trust in Ahn and Esarey (2008). For simplicity, we refer to Lemma 2 and omit the strategies of the subgame of trust at stage 3 of Γ. For a type distribution $\lambda \in [0, 1]$, let PBE(λ) denote the PBE of the game, i.e. a pair $(\mathbf{d}, \omega)$ that satisfies Definition 1.

Definition 2. *An evolutionarily stable perfect Bayesian equilibrium (EPBE) is a PBE in which both trustworthy and non-trustworthy types earn the same payoffs or only one type remains in the population and the other type cannot enter the poulation without having a lower payoff than the other type. More formally, an evolutionarily stable perfect Bayesian equilibrium is given by a type-contingent strategy profile* $\mathbf{d} = (d^L, d^H)$*, beliefs* $\omega(\theta^i \mid s, d^L, d^H)$*, and* $\lambda \in [0, 1]$ *such that*

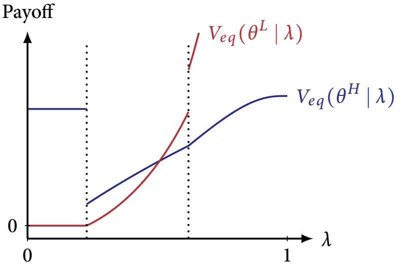
i) $(\mathbf{d}, \omega) \in PBE(\lambda)$ *and*

ii) $V(\theta^L, \mathbf{d} \mid \lambda) \geq V(\theta^H, \mathbf{d} \mid \lambda)$ *and* $V(\theta^H, \mathbf{d} \mid \lambda) \geq V(\theta^L, \mathbf{d} \mid \lambda)$.

Consider drinking as a binary choice. Let $\underline{\lambda}$ and $\bar{\lambda}$ denote the threshold values for λ as used in Proposition 1. The expected payoff of player 2 at stage 3 of Γ for given λ, given



(a) A pooling equilibrium without drinking



(b) A pooling equilibrium with drinking

Figure 9: Pooling equilibrium without drinking: $\beta_1 = \beta_2^L = 2$, $\tau_1 = \tau_2 = 1$, $\mu^H = 1$, $\sigma(0) = 1$, $\sigma(1) = 65/100$, $c = 7/100$. Pooling equilibrium with drinking: $\beta_1 = 2$, $\beta_2^L = 5$, $\tau_1 = \tau_2 = 1$, $\mu^H = 1$, $\sigma(0) = 1$, $\sigma(1) = 7/10$, $c = 5/100$.

equilibrium values for **d**, is then

$$V_{eq}(\theta^L \mid \lambda) = \begin{cases} 0 & \text{if } \lambda \in [0, \underline{\lambda}] \\ V(\theta^L, 1, 1) & \text{if } V(\theta^L, 1, 1) \in (\underline{\lambda}, \bar{\lambda}] \\ V(\theta^L, 0, 0) & \text{if } V(\theta^L, 1, 1) \in (\bar{\lambda}, 1] \end{cases} \tag{17}$$

$$V_{eq}(\theta^H \mid \lambda) = \begin{cases} V(\theta^H, 0, 1) & \text{if } \lambda \in [0, \underline{\lambda}] \\ V(\theta^H, 1, 1) & \text{if } V(\theta^L, 1, 1) \in (\underline{\lambda}, \bar{\lambda}] \\ V(\theta^H, 0, 0) & \text{if } V(\theta^L, 1, 1) \in (\bar{\lambda}, 1], \end{cases} \tag{18}$$

where it is assumed that at $\underline{\lambda}$ the equilibrium is separating and at $\bar{\lambda}$ the equilibrium is pooling with drinking. Assuming that both types can survive, the evolutionarily stable type distribution is given by the λ that solves $V_{eq}(\theta^L \mid \lambda) = V_{eq}(\theta^H \mid \lambda)$. Figure 9 shows two examples, illustrating that pooling equilibria with and without drinking can arise. However, a separating equilibrium cannot be evolutionary stable: in a separating equilibrium, the payoff of the non-trustworthy types at stage 3 of the game Γ is zero, while the payoff of the trustworthy types is positive. Therefore the trustworthy types will thrive until λ is high enough to render seperation impossible.

It should also be noted that an EPBE in pure strategies may not exist at all, as illustrated in Figure 10. The discontinuity of the function $V_{eq}(\theta^L \mid \lambda)$ is due to the abrupt change from drinking to non-drinking. In this case we may observe cyclic patterns of pooling equilibria with and without drinking (see also Section 5).

5 DISCUSSION AND POSSIBLE EXTENSIONS

5.1 *Separating vs. Pooling Equilibria*

Both separating and pooling equilibria can arise in the model presented in Section 3. But in many western countries few people remain completely abstinent, and it does not

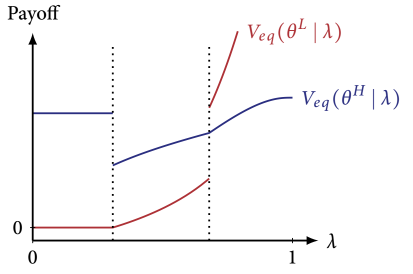


Figure 10: An equilibrium may not exist (example with $\beta_1 = 2$, $\beta_2^L = 3$, $\tau_1 = \tau_2 = 1$, $\mu^H = 1$, $\sigma(0) = 9/10$, $\sigma(1) = 1/2$, $c = 9/100$).

appear to be likely that those who do remain abstinent are not trustworthy. Hupkens et al. (1993) find that within the European Community the average percentage of alcohol abstainers is 10.8% for men and 22.3% for women; see Bloomfield et al. (2003) for a recent survey of international comparisons. The pooling situation therefore appears to be a more realistic description of reality. This is in accordance with the finding that separating equilibria are not evolutionarily stable.

Furthermore, there is some support of the hypothesis of cyclic patterns in social drinking due to the non-existence of an evolutionarily stable equilibrium, as wave-like variations in alcohol consumption are indeed observed (see Skog 1986).

5.2 *Countersignaling*

Feltovich et al. (2002) introduce the notion of *countersignaling*: In a model with an exogeneous noisy signal and at least three different types the highest types might choose to not invest into an endogeneous signal. The intuition is that the highest types have reasons to be confident that their noisy signal identifies them as high types; investing into the endogeneous signal would pool them with the medium types. Non-drinkers who are otherwise easily recognized as trustworthy might take consolation in the idea that they are countersignaling.

5.3 *Competing Drugs*

Suppose that to correctly interpret drug-induced behavior it requires some knowledge about the particular technology employed by the players which is obtained due to socialization and experimentation. If players can only obtain knowledge about one drug, then inefficiency will arise if many different drugs are used by different players. Suppose two players who have "specialized" in different drugs are matched at state 2 of the game. These players will not be able to reveal any information about themselves. This will benefit the types who are not trustworthy at the expense of those who are trustworthy. If the trustworthy types are the majority, society may be able to enforce, via laws or norms, the use of a single drug.

5.4 *Exploitation and Reciprocity*

In the model in Section 3 only trustworthiness was analyzed. If intoxication of one player can by exploited by another player, players can also signal trust by using the drug. It is also possible that the ability of player i to exploit the intoxicated player j decreases with player i's own intoxication. In that case using the drug together and simultaneously can decrease the risk of being exploited for both players. In the case of alcohol, this can be easily achieved by taking one sip at a time and waiting for the other player to follow in suit. Staying only one sip ahead of the other player does not lead to a high risk of exploitation.

5.5 *Religion and Alcohol*

There is evidence that religion, in particular participation in religious rituals, can signal trustworthiness or, more generally, prosocial preferences. Sosis (2003) provides a simple graphical model of this idea. Ruffle and Sosis (2007) test the hypothesis with experiments conducted in secular and religious kibbutzim; their results confirm the hypothesis, although the alternative hypothesis that it is religious participation per se that causes prosociality could not be rejected. The hypothesis that religiosity is useful as a signal for trustworthiness was directly tested by Tan and Vogel (2008) in a laboratory experiment; the authors find convincing evidence in support of the hypothesis. See Norenzayan and Shariff (2008) for a recent survey of the research in this field.

Many religions recommend or require abstinence from drugs; the most prominent example with regard to alcohol (or, more exactly, *khamr*) is Islam.[8] Patock-Peckham et al. (1998) find that college students without religious affiliation report higher levels of drinking frequency and quantity than non-religious students; the difference exists also for perceived drinking norms. Lorch and Hughes (1985) find that religion is not a strong predictor of drug use of young people in general, but they do find that religion is strongly related to alcohol use, and that fundamentalists have the lowest percentages of drug use in general.

If signaling of trustworthiness is an important aspect of both religion and moderate alcohol consumption, then religion and alcohol are to some extent substitutes. If it is the signaling aspect of religion that contributes to the stability of religious groups, religious leaders who are concerned about the success and stability of their religion have an incentive to discourage the use of alcohol or similar technologies.

6 CONCLUSION

This paper introduced an illustrative model to analyze social drug consumption and to propose that one reason for this phenomenom can be found in information economics. Alcohol seems to be particularly well suited as it does not only faciliate social interaction and type revelations, but is also not addictive for moderate consumption, has mostly short term effects, and allows a gradual degree of loss of control which can be easily observed and reciprocated by others. The model is also novel from a more technical point

[8] See Michalak and Trocki (2006) and Deuraseh (2003) for an overview.

of view, as we modeled the strategic improvement of the informational content of a noisy exogenous signal.

The model presented in this paper includes a noisy signal about personality types. Drinking has an impact on the distribution of the signal; specifically, it was assumed that drinking reduces the standard deviation of the noisy signal. It was shown that fully separating equilibria exist in populations with large fractions of trustworthy types. Pooling equilibria with and without drinking can exist in populations with small fractions of trustworthy types. In a long run evolutionary equilibrium only pooling equilibria can persist.

A APPENDIX

Let

$$A := \left[\frac{1-\lambda}{\lambda}\right]\frac{\beta_1}{\tau_1}. \tag{19}$$

The error function is denoted $\mathrm{erf}(x)$ and the complementary error function is denoted $\mathrm{erfc}(x) = 1 - \mathrm{erf}(x)$. We denote $q^L = q(\theta^L, \mathbf{d})$ and $q^H = q(\theta^H, \mathbf{d})$. We have

$$\begin{aligned} q^H &= ½\ \mathrm{erfc}\left(\frac{-[\mu^H/2] + [\mu^H]^{-1}\,\sigma(d)^2\,\log(A)}{\sqrt{2}\,\sigma(d)}\right), \\ q^L &= ½\ \mathrm{erfc}\left(\frac{[\mu^H/2] + [\mu^H]^{-1}\,\sigma(d)^2\,\log(A)}{\sqrt{2}\,\sigma(d)}\right). \end{aligned}$$

Proof of Lemma 4 Continuity is obvious. We have

$$\frac{\partial q^H}{\partial \lambda} = \frac{\sigma(d)\ \exp\left\{-\frac{\left[(\mu^H)^2 - 2\,\sigma(d)^2\,\log(A)\right]^2}{8\,(\mu^H)^2\,\sigma(d)^2}\right\}}{\sqrt{2\pi}\,(1-\lambda)\,\lambda\,\mu^H};$$

it is easy to check that this expression is positive except for the limiting cases of $\lambda \to 0$ and $\lambda \to 1$, where the expression is zero. The proof for q^L works analogously. ■

Proof of Proposition 1 The λ^* which solves $½\ \tau_2[1 - q(\theta^H, 0, 0)] = c$ is

$$\lambda^* = \beta_1\left[\beta_1 + \tau_1\ \exp\left\{\frac{[\mu^H]^2 + 2\sqrt{2}\,\mu^H\,\sigma(0)\,\mathrm{erfc}^{-1}\,(2 - [4\,c/\tau_2])}{2\,\sigma(0)^2}\right\}\right]^{-1}.$$

Obviously, for $\infty > \tau_1 > 2$ and $c = 1$, $\lambda^* \in (0,1)$. The $\lambda^\dagger$ which solves $½\ q(\theta^L, 1, 1)\,\beta_2^L = c$ is

$$\lambda^\dagger = \beta_1\left[\beta_1 + \tau_1\ \exp\left\{\frac{-[\mu^H]^2 + 2\sqrt{2}\,\mu^H\,\sigma(1)\,\mathrm{erfc}^{-1}\left(4\,c/\beta_2^L\right)}{2\,\sigma(1)^2}\right\}\right]^{-1}.$$

Again, for $\infty > \beta_2^L$ we have $\lambda^\dagger \in (0,1)$.

The condition $\lambda^\dagger > \lambda^*$ is equivalent to

$$\exp\left\{\frac{-[\mu^H]^2 + 2\sqrt{2}\,\mu^H\,\sigma(1)\,\mathrm{erfc}^{-1}\left(4\,c/\beta_2^L\right)}{2\,\sigma(1)^2}\right\} >$$
$$\exp\left\{\frac{[\mu^H]^2 + 2\sqrt{2}\,\mu^H\,\sigma(0)\,\mathrm{erfc}^{-1}\left(2 - [4\,c/\tau_2]\right)}{2\,\sigma(0)^2}\right\}$$

which (with $c = 1$) reduces to

$$\sigma(1)\,\mathrm{erfc}^{-1}\left(2 - \frac{4}{\tau_2}\right) - \sigma(0)\,\mathrm{erfc}^{-1}\left(\frac{4}{\beta_2^L}\right) > \frac{\mu^H\,\left(\sigma(0)^2 + \sigma(1)^2\right)}{2\sqrt{2}\,\sigma(0)\,\sigma(1)}$$

For the left hand side to be positive, it suffices that $\beta_2^L > 4$ and $(2\,\beta_2^L)/(\beta_2^L - 2) > \tau_2 > 2$. The right hand side can be arbitrarily close to zero.

Because erfc is a decreasing function, we have $q(\theta^H,1,1) > q(\theta^H,0,0)$ if

$$\log(A) > -\frac{(\mu^H)^2}{2\,\sigma(0)\,\sigma(1)}$$

which given the restrictions on a the parameters is equivalent to $0 < \lambda < \lambda^\diamond$ where

$$\lambda^\diamond := \beta_1\left[\beta_1 + \tau_1\,\exp\left\{-\frac{(\mu^H)^2}{2\,\sigma(0)\,\sigma(1)}\right\}\right]^{-1}.$$

Note that $q(\theta^H,1,1) > q(\theta^H,0,0)$ is sufficient for ½ $q(\theta^H,1,1)\,\tau_2 - c >$ ½ $q(\theta^H,0,0)\,\tau_2$ because τ_2 can be arbitrarily large. What remains to be shown is $\bar{\lambda} < \lambda^\diamond$, which given the restrictions on the parameters is equivalent to

$$\mathrm{erfc}^{-1}(2 - [4\,c/\tau_2]) < \frac{\mu^H\,(\sigma(0) + \sigma(1))}{2\sqrt{2}\,\sigma(0)\,\sigma(1)}.$$

The right hand side is positive, whereas $\mathrm{erfc}^{-1}(2 - [4\,c/\tau_2]) = 0$ for $\tau_2 = 4$ and $c = 1$ and decreases in τ_2. Finally, $\lambda^\diamond < 1$ is obvious. ■

REFERENCES

Ahn, T. and J. Esarey (2008): "A Dynamic Model of Generalized Social Trust," *Journal of Theoretical Politics* 20(2):151–180.

Berg, J., J. Dickhaut, and K. McCabe (1995): "Trust, Reciprocity, and Social History," *Games and Economic Behavior* 10(1):122–142.

Bloomfield, K., T. Stockwell, G. Gmel, and N. Rehn (2003): "International Comparisons of Alcohol Consumption," *Alcohol Research and Health* 27(1):95––109.

Bolle, F. (1998): "Rewarding Trust: An Experimental Study," *Theory and Decision* 45(1):83–98.

Bolle, F. (2001): "Why to Buy Your Darling Flowers: On Cooperation and Exploitation," *Theory and Decision* 50(1):1–28.

Deuraseh, N. (2003): "Is Imbibing Al-Khamr (Intoxicating Drink) for Medical Purposes Permissible by Islamic Law?" *Arab Law Quarterly* 18(3/4):355–364.

Feldman, W. M. (1927): "Alcohol in Ancient Jewish Literature," *Addiction* (formerly *The British Journal of Inebriety*) 24(3):121–124.

Feltovich, N., R. Harbaugh, and T. To (2002): "Too Cool for School? Signalling and Countersignalling," *RAND Journal of Economics* 33(4):630–649.

Frank, R. H. (1987): "If Homo Economicus Could Choose His Own Utility Function, Would He Want One with a Conscience," *American Economic Review* 77(4):593–604.

Friedman, D. and N. Singh (2009): "Equilibrium Vengeance," *Games and Economic Behavior* 66(2):813–829.

Fudenberg, D. and J. Tirole (1991): *Game Theory*, Cambridge, MA: MIT Press.

Higgins, S. T. and M. L. Stitzer (1988): "Effects of Alcohol on Speaking in Isolated Humans," *Psychopharmacology* 95(2):189–194.

Hupkens, C. L. H., R. A. Knibbe, and M. J. Drop (1993): "Alcohol Consumption in the European Community: Uniformity and Diversity in Drinking Patterns," *Addiction* 88(10):1391–1404.

Lorch, B. R. and R. H. Hughes (1985): "Religion and Youth Substance Use," *Journal of Religion and Health* 24(3):197–208.

Michalak, L. and K. Trocki (2006): "Alcohol and Islam: An Overview," *Contemporary Drug Problems* 33(4):523–562.

Norenzayan, A. and A. F. Shariff (2008): "The Origin and Evolution of Religious Prosociality," *Science* 322(5898):58–62.

Nutt, D., L. A. King, W. Saulsbury, and C. Blakemore (2007): "Development of a Rational Scale to Assess the Harm of Drugs of Potential Misuse," *The Lancet* 369(9566):1047–1053.

Patock-Peckham, J. A., G. T. Hutchinson, J. Cheong, and C. T. Nagoshi (1998): "Effect of Religion and Religiosity on Alcohol Use in a College Student Sample," *Drug and Alcohol Dependence* 49(2):81–88.

Paton-Simpson, G. (2001): "Socially Obligatory Drinking: A Sociological Analysis of Norms Governing Minimum Drinking Levels," *Contemporary Drug Problems* 28(1):133–177.

Rolleston (1927): "Alcoholism in Classical Antiquity," *Addiction* (formerly *The British Journal of Inebriety*) 24(3):101–120.

Ruffle, B. J. and R. Sosis (2007): "Does It Pay To Pray? Costly Ritual and Cooperation," *The B.E. Journal of Economic Analysis & Policy* 7, Article 18(1).

Skog, O.-J. (1986): "The Long Waves of Alcohol Consumption: A Social Network Perspective on Cultural Change," *Social Networks* 8(1):1–32.

Sosis, R. (2003): "Why Aren't We All Hutterites? Costly Signaling Theory and Religious Behavior," *Human Nature* 14(2):91–127.

Szwed, J. F. (1966): "Gossip, Drinking, and Social Control: Consensus and Communication in a Newfoundland Parish," *Ethnology* 5(4):434–441.

Tan, J. H. W. and C. Vogel (2008): "Religion and Trust: An Experimental Study," *Journal of Economic Psychology* 29(6):832–848.

Walsh, C. E. (2000): "Under the Influence: Trust and Risk in Biblical Family Drinking," *Journal for the Study of the Old Testament* 90:13–29.